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Navy PWC Yokosuka's Recipe for Building a GIS

by Ayman S.A. El-Swaify, P.E., Navy Public Works Center, Yokosuka, Japan

This article is based on a presentation I gave at the January 2000 Japan GIS Working Group Meeting. I took a creative bent on the presentation approach, and I hope you find it enjoyable and helpful reading.

As a prelude, it is important to note that our GIS implementation is on behalf of the entire Navy Region in Japan (covering about 20 separate bases) and focuses on facilities management. We are following an enterprise implementation approach that will meet the diverse requirements of facility managers and grow to accommodate ever-increasing amounts of facilities data.

—Ayman S.A. El-Swaify

Building a successful geographic information system (GIS) is very much like preparing for a banquet. Just as careful planning and selection of the guest list, menu, and table arrangements enhance a banquet, so will timely planning and selection of all components of a GIS lead to successful implementation. To explain this analogy, I have broken down the "banquet preparation" into the following sections:

- Hosts (staffing)
- Guests (users)
- Table Setting (hardware)
- Appetizers (software)
- Main Course (land base data)
- Side Dishes (data for utilities, environmental, etc.)
- Starches (associated documents)
- Serve (applications)

Hosts (staffing)

At Public Works Center (PWC) Yokosuka, our GIS Management staff presently consists of one U.S. Civil Service (USCS) and two Japanese National positions covered under the Government of Japan Master Labor Contract (MLC). We are presently attempting to add one more MLC position to the staff. We do not maintain any contractor personnel onsite on a full-time basis. In addition to the GIS Management responsibility, the function of the USCS position is to serve as a liaison with upper management, sell services to military customers, and grow the GIS business. The MLC positions support the day-to-day responsibility of managing the operation, learning and applying new technology, assisting users, etc.

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We are able to manage our implementation with a relatively small staff because the responsibility for data maintenance is placed with data owners in concert with existing work processes.

Guests (users)

Without guests, there would be no party. Our GIS management staff take the time to get to know the end users, create awareness of GIS technology and its benefits, understand their operation, and identify existing data sources and the best opportunities for payback. What we have found to be very important is empathizing with the natural reluctance of users to accept a new way of doing business. Whenever interest in GIS expands to a new area, we usually perform a simple needs analysis in order to brief users and determine their requirements.

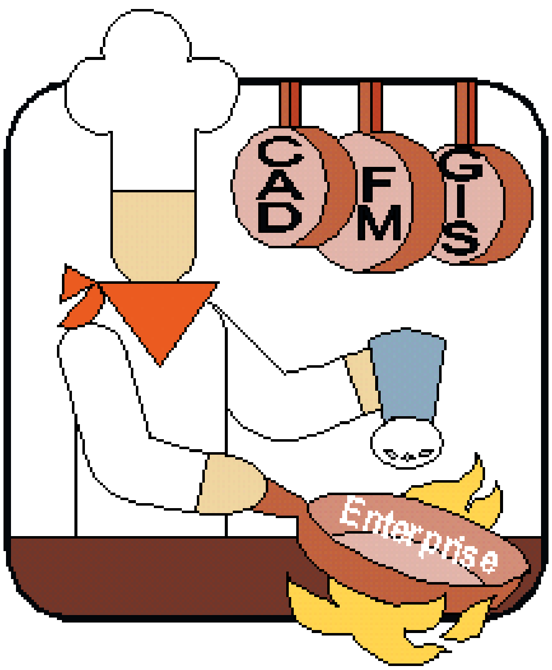

Table Setting (hardware)

Our command network uses 100BaseT between servers (backbone) and switched 10baseT to the desktop. However, all wiring in place will support 100BaseT to the desktop as equipment is procured. We have three file servers devoted to the GIS – a GIS data server, a GIS database server (which hosts an Oracle 8*i* database), and a GIS Web server. Workstations are Windows NT version 4 and a Pentium II with 128 MB RAM. All users are assigned 21-in. monitors. The GIS data directory structure on the data server is set up to support a systematic and logical placement if data are in support of the system. For more details, see the article in the September 1999 issue of the *CADD/GIS Bulletin*.

Appetizers (software)

We are still primarily a computer-aided drafting (CAD)-based organization. All data maintenance takes place in the CAD environment. We are presently using AutoCAD R14 and plan to upgrade to AutoCAD 2000 within the next 2 months.

Our initial foray into the GIS arena was based on the ESRI ArcCAD software package, which runs inside of AutoCAD. However, with the release of ESRI's impressive ArcInfo 8 desktop package, we have made the decision to begin a transition to this platform and will do so over the course of this year.

Our primary GIS software platform is ESRI's ArcView GIS. ESRI ArcView IMS 1.1 has been used for the past 2 years to make map data available to all users within the organization. We have not focused a lot of attention on the Web platform to date, but the emphasis will probably start shifting in that direction later this year. At that time, we will evaluate the use of the ESRI ArcIMS software package.

Main Course (land base data)

From a facilities management point of view, the most important piece is the base map. As an organization, initial attention must be focused on the best method for obtaining an up-to-date, spatially accurate, geo-referenced, topologically correct, spatially contiguous, spatial-data-standard (SDS)-compliant land base. Yes, this is a mouthful, but the words are all important. Here are some definitions:

- "Up-to-date" – The map should be no more than 2 years old. Keep in mind that old data are the biggest enemy to your implementation.
- "Spatially accurate" – Basically, you could overlay survey data onto your map with reasonable results. For us, that means accuracy within plus or minus ½ m.
- "Geo-referenced" – The map is in a valid projection and coordinate system. This facilitates the addition of new data and maintenance of existing data.

The CADD/GIS Technology Center for Facilities, Infrastructure, and Environment is dedicated to fostering the application of computer-aided design and drafting (CADD) and geographic information system (GIS) technologies for facility life-cycle efforts throughout the Army, Navy, and Air Force. The CADD/GIS Bulletin *is published by The CADD/GIS Technology Center for Facilities, Infrastructure, and Environment of the Information Technology Laboratory, U.S. Army Engineer Research and Development Center, 3909 Halls Ferry Road, Vicksburg, Mississippi 39180-6199.*

- "Topologically correct" – The features that make up the map are drawn in a way that permits the GIS to recognize and use them properly. For example, buildings must be drawn as a closed polygonal boundary where all corners match exactly. Topology is the biggest barrier to using legacy CAD data in GIS.
- "Spatially contiguous" – To the fullest extent possible, it is important for the land base to be seamless. All adjacent areas should be together in a single coverage. In the "old" days, areas were split up to keep file size at a minimum.
- "SDS compliant" – Features should be named, broken out, and/or aggregated in accordance with the latest release of the CADD/GIS Spatial Data Standards. If you are reading this article, then you are most likely familiar with what these are.

So how does one go about obtaining such a land base? Well, there are three common approaches:

- Use a legacy CAD map. This is usually a good source of current information. However, in most (but certainly not all) cases, the CAD map was created from a hardcopy drawing at a scale not amenable to spatial accuracy. Before committing any investment toward building topology into such a data source, it is absolutely critical to validate the spatial accuracy of the source. This procedure can be done by placing the drawing in a real-world coordinate using known points and then validating other locations using survey data. Some degree of distortion can be solved with technologies such as "rubber-sheeting," but I can tell you from first-hand experience that these are not suitable solutions if your CAD map is way out of whack.
- Digitize a new map from "good" hardcopy drawings. "Good" means recent and at a reasonable scale. Recent drawings at a scale of 1:500 (1 in. = 50 ft.) or better that were generated from aerial photography are good candidates. A scale of 1:1000 (1 in. = 100 ft.) may also work depending on the visibility of features that need to be captured from the drawings. Recent drawings are important, because if things have changed a lot since the drawings were created, then you will have to invest additional effort into bringing everything up-to-date. If you are going to digitize the drawings in-house, then you will also need the software tools to scan and digitize the drawings. We did this in-house for a few of our sites, and it proved to be a cost-effective solution.
- Aerial photography and photogrammetry. This is usually the most costly solution, but is certainly the best way to obtain up-to-date, accurate data.

Regardless of the solution you choose, be sure to figure out the data maintenance issues right up front so that you can preserve your investment in acquiring the data. In our case, the responsibility was assigned to our Real Estate Group. Others have placed the function within the Engineering Group. It is important that the group assigned this responsibility be responsive to making changes. Typically, an engineering staff is preoccupied with many urgent projects that preclude the updates to the base map.

Once, you have your land base in place, the next step is to apply a practical identification scheme to your facilities. In our case, we used data elements from the Navy Facilities Assets Database, data elements 001 and 005, which make a unique identification for a facility. The Navy is also considering adding a new data element to serve as the unique facility identifier.

Also necessary for the maintenance of the base map is the installation of appropriate survey monuments. These will facilitate the collection of properly geo-referenced data points that can be used to update the base map. A dense grid should be planned, installed, and surveyed. Then these points should be laid out on top of the land base.

Side Dishes (data for utilities, environmental, etc.)

Once the land base is in place and being maintained, the fun can really begin. In the facilities management arena, the typical data layers that will be added to the land base first are utilities and environmental data. For any of these, the basic steps to add the data are similar:

- Assess existing sources (CAD, hardcopy).
- Overlay features onto the land base, visually adjusting spatial locations. Assign unique identification to all features that will be related to external tabular data sources.
- Accommodate existing annotations as attributes.
- Place on the GIS data server in prescribed directory structure.
- Conduct surveys as required to add and update feature locations and attributes.

As with the land base data, it is extremely important to implement data maintenance procedures as close as possible to the owners of the data.

Starches (associated documents)

Identify useful documentation being compiled by various departments that can be associated with the land base or other map features. Examples are photos, elevations, floor plans, HTML, and scanned documents, schematics, renderings, etc. Establish a naming and directory convention on your GIS data server. Set up procedures for users to post and maintain these documents accordingly. Implement an appropriate application for users to be able to find and display these reference items and gain additional information about map features.

Serve (applications)

Evaluate the pros and cons of commercial-off-the-shelf (COTS)-centered and development-centered options. Decide which to pursue. At PWC Yokosuka, our initial GIS development has been centered around the COTS ArcView GIS package. While keeping development costs to a minimum, it has also hindered a wider deployment of the system because of the need to purchase and install the ArcView software on users' computers. However, the use of this software in the beginning has enabled us to focus more attention on our data sets. Of course, even a minimal amount of customization will be required in a COTS-centered implementation. However, use discretion in duplicating the capabilities of the software.

A development-centered approach may use software such as ESRI's MapObjects, which can be used as a library to Visual Basic, Delphi, or C. This type of implementation can be more costly up front unless you have in-house resources to devote to the development tasks. In addition, unless development is planned in an organized manner, the code can become messy and difficult to maintain over time. The advantage is that you will be able to get the system in front of a large audience at less cost per seat.

It is also very important to follow a portable spec for your system implementation and development (see the September 99 issue of the *CADD/GIS Bulletin* for a description of the particular portable approach we are using for the Navy in Japan). Take it from me - you want to think this way at the very start of your implementation. Otherwise, you will be rebuilding pieces about a year or two into your implementation.

Some of the elements of a portable spec are the following:

- It is base-independent. It can run just as effectively if an entirely different land base is used.
- All coding is modular and outside of the project. Modules can be loaded and unloaded as required by users. In this manner, users can set up their preferred working environment to suit their specific requirements.
- System variables are used to point to locations of data sets (i.e., no hard-coded paths).
- Configuration files are used by managers to add data and configure the application. Coding does not have to be revisited except to add functionality.
- The application can be configured without modifying program code.

To ensure that a particular application or program module is portable, test them with more than one data set and do all you can to "break" the application. It is better that you discover the problems before your users do.

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CADD/GIS Symposium and Exposition 2000

by Harold Smith, Chief
The CADD/GIS Technology Center for Facilities, Infrastructure, and Environment

It's a fact! With over 1,100 attendees, the CADD/GIS Technology Symposium and Exposition 2000 held May 22-25 in St. Louis, MO, was a big success. Throughout the course of the week, attendees had a choice of attending over 150 presentations, learning in 19 workshops, and visiting over 100 exhibition booths. If there was any complaint about the Symposium, it would be that there were so many great presentations and exhibits it was hard to see them all.

The Symposium got off to a great start with a powerful presentation from John Voeller, Senior Vice President of Information Technology at Black and Veatch, Kansas City, MO, on the government's and industries' lack of preparation for upcoming technologies; and ended with a humorous but insightful presentation by John Kiker entitled "Everything I Need to Know for CADD Management I Learned from Cartoons and Star Trek."

An Ice Breaker held the first night of the Symposium in the Exhibit Hall included lots of great food and a scavenger hunt, with the prize being a new Palm Pilot. During the week, several attendees took advantage of the gathering of talent and knowledge and held meetings on CADD/GIS technologies during the off-hours of the Symposium.

To see some of the presentations, please visit the Center's Web site at http://tsc.wes.army.mil. Many of the presentations are available in PowerPoint and can be easily viewed.

I would like to thank everyone who participated in the Symposium and especially the Installation Management Facilities CAD2 group for their financial support. It was through your support that the event turned out to be both a successful and educational experience.

The Web Mapping Technology Initiative: A Public-Private Partnership

by Daniel L. Specht, Topographic Engineering Center

The Web Mapping Technology (WMT) initiative is a collaborative effort between military and civil government agencies, international standards organizations, academic institutions, and the commercial geoprocessing technology sector to develop interoperable Web mapping technology solutions. The initiative will advance the state of proprietary Web mapping technology, enabling Web-based mapping to support applications that require access to multiple, distributed geospatial information sources across the World Wide Web and secure networks. Applications for this technology include environmental analysis and management, disaster relief operations, emergency response and management, and military operations.

The WMT initiative develops software components implementing common interfaces necessary for multi-source geospatial information discovery, display, and interaction. These components support diverse applications across the spectrum of Web user environments, ranging from enterprise intranets to home users on dial-up connections.

As of July 2000, the main technology elements developed by the WMT initiative are the OGC Web Map Server (WMS) Interface Specification [1] and the OGC Geography Markup Language (GML) Recommendation Paper [2]. WMS is a simple, effective way to format spatial context, query, and server capabilities messages across all networks or Webs. GML is a simple, industry-standard, Web-optimized transport format for geospatial information. Now that the first development and testing cycle is completed (WMT 1), there are commercial companies ready to sell components that will interoperate according to these specifications. There are also several "shareware" interoperable components available. Many U.S. Federal agencies have already started extending major databases to serve online geospatial information using this technology, and U.S. Army-funded efforts are helping to build the first integrating framework of interoperable components to deliver this information to potential users [3]. Additional development efforts are underway and will result in new technologies to complement WMS and GML.

Interoperable technologies like the WMS Interface Specification enable users to access and exploit a wide variety of geodata on demand from civil and military sources. The costs of interoperable frameworks compared to stove-piped systems are significantly less because information and services are reusable, modular, and extensible. The technology will also provide improved methods to synchronize and communicate the Common Operational Picture in network-centric environments.

For additional information, please contact Dan Specht at 703-428-6761 or *Daniel.L.Specht@tec02.usace.army.mil*.

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Geospatial Dreaming

by M. Rose Kress, Ph.D., Environmental Characterization Branch, Environmental Laboratory

(Early one Monday morning, at the Lake Two-Step Resource Management Office.)

Harold: Good morning, everybody! This place looks like a mad house! What's going on?

Laurel: That's what you get for taking a week off and not checking your e-mail. I have seven actions that must be checked on today. Two encroachment complaints, two permit requests, an apparent effluent violation, a bank erosion problem, and an eagle nest sighting. And that's just what's left over from last week. On top of that, the District moved up the date to complete the updated sign inventory, the national automated reservation service double-booked one of our campgrounds, David and Nancy are out with the flu, and I have a headache. Well, you're the boss. What do we do?

Harold: Whew! Guess I'll get some coffee. Is Rose here? We are going to need a lot of map and survey support to get all this done.

Laurel: She's back in the map room. Been camped out in there all weekend. All that new GIS and GPS stuff showed up last week. She acted like it was Christmas in July.

(Knock. Knock. Shuffle. Shuffle.)
Harold: Rose? Are you in here? I brought some coffee for you.

Rose: Hey, Boss. Come back here. You have to see this. Guess what this is on the screen?

Harold: It looks like the new GIS map data for the area around the Dancing Bluff Campground. I see you finally got a copy of it from the District.

Rose: Better than that! It's the actual digital data stored in our Enterprise GeoBase at the District office. It's displaying, real time, right here on my computer. Look, they are using all the Spatial Data Standard entities and feature names and attribute tables. That makes it so easy to find the data we need.

Harold: That display is fast. Did you get new modems, too?

Rose: No. Even from 200 miles away over a modem, this new thin-client architecture makes it seem like I am sitting right there in the District office directly connected to the GIS server.

Harold: OK, that sounds fantastic, but I believe you. What are all those red spots and that blinking dot?

Rose: This is so cool! Those red spots are the locations of all permitted outfalls to the lake and that green blinking dot is Toby. He took one of the new GPS units and went to check on that effluent violation on Laurel's list. He's transmitting his GPS location continuously back to me over the wireless connection we set up.

(Ring, Ring.)
Rose: Hello, Lake Two-Step Project Office.

Toby: Rose, Toby here. I'm on the cell phone. Are you getting my GPS signal?

Rose: I am. It looks like there are three outfall permits right around that area. I have all the permits within 2 miles up and down river of you on our Intranet Web-mapping site ready for you to display. If you use your wireless to connect to the Web-map and redirect the GPS signal to your field GIS, you can start to zero in on that violation report. Looks like it may be a false alarm. By the way, the guy who saw the eagle nest came by and pointed to the location on a map. I have an approximate point location for that sighting on our Web-map page, also. Can you run by there and take a look? Meanwhile, I will dig up the GIS file with the known eagle nests.

Toby: Great. Will do. If all this new stuff keeps working, we are going to make short work of Laurel's list. Bye.

Harold: Field GIS? Wireless GPS? Thin-client? Web-map? Enterprise GeoBase? I was only gone a week, but I feel like Rip Van Winkle. What else on this list can you help with?

(Ring. Ring.)
Rose: Excuse me, Boss. Hello. Lake Two-Step Project Office.

Stephen: Rose, Stephen here. I'm on the cell phone. This MapPad with the laser range finder is working very well. I have logged in 20 signs already. Only 80 more to go. I wish we had had it for the first 300 signs. Being able to control the whole sign inspection and inventory using this touch screen means I don't even have to get out of the truck! Finally a small, mobile GIS/GPS for my vehicle! This is making the sign inventory almost fun, but I seem to have lost the connection to the digital camera. Have any suggestions?

Rose: I have not read the whole manual on the MapPad yet, Stephen. Keep taking the digital pictures and if you have to, just enter the digital photo number into the MapPad by hand. It will still be a lot faster than the old way. With selective availability turned off, you should be getting sub-meter accuracy with your GPS unit. This will be the most accurate sign inventory we have ever done. Will you be finished by lunch? Laurel's list is getting longer.

Stephen: By lunch? Sure. Then I'll be in and we can dump the data I collected this morning using the MapPad into your desktop GIS, and you can run the QA/QC on it. Bye.

Harold: Mobile MapPad? Sub-meter accuracy? Am I dreaming?

Rose: No, Boss, not dreaming! We are really taking advantage of this field friendly geospatial technology. Wait until you see this next one. I checked the Corps-wide satellite image acquisition schedule, and guess what? Lake Two-Step was imaged yesterday by one of the 1-m satellites. The image is already in the Enterprise GeoBase. I am displaying it from the District server now. Do you want to see that bank erosion area Laurel logged in? We can compare it against the last image to see how much we lost. Denise thinks there are some cultural resources very near the erosion site. I want to display the archeological sites over this image, but I need your password to link to the secure portion of the GeoBase to get them.

Harold: One-meter satellite image, collected yesterday and on your screen today? Looks like you have Laurel's list under control. What do I need to do?

Rose: Well. . . . You could go talk to those angry double-booked campers.

Harold: All right. Just, one more question. Who said Toby could have a cell phone . . .?

(Snore... Snore...)
Pete: Rose (*Shake. Shake.*). ROSE! (*SHAKE! SHAKE!*). ***ROSE! WAKE UP!*** **You're going to be late for work!**

Rose: Uh? What? Oh no, it was only another dream....

The dream world of Lake Two-Step is not as far away as it may seem. Many of the geospatial technologies mentioned — mobile GIS, wireless GPS, high-resolution imagery delivered near real time — will soon be available in a form suitable for use in field offices. The U.S. Army Corps of Engineers maintains nearly 300 individual management offices at various water control and navigation projects throughout the country. One goal of the Corps' Geospatial Technology Research and Development Program is the successful integration and transfer of these emerging geospatial technologies into those field offices. Dr. Rose Kress of the Environmental Laboratory, U.S. Army Engineer Research and Development Center, is the principal investigator for the effort. She is designing a geospatial technology package, in partnership with the CADD/GIS Technology Center, that can effectively support the day-to-day workload of the on-the-ground managers, rangers, and technicians that staff these busy field offices. You can wake Rose up by e-mail at *Rose.M.Kress@erdc.usace.army.mil.*

Object Standards: An Overview of Object Standardization

by Warren R. Bennett, Computer Science Division, Information Technology Laboratory

The CADD/GIS Technology Center is a leader in developing and disseminating advanced CADD and GIS standards, products, and technology. The Center is initiating a project called the Consolidated Object Strategy that will affect industrial standards used by all engineering software products. This project will participate with national and international standards organizations to develop standards for objects used in CADD and GIS software products.

Nature of Objects

Software vendors are rapidly touting their products as being object-oriented. Object technology is taught in college and is used in all new software. Web pages are built using the basics of object technology. The new programming language, Java, is a means to implement object technology. To understand the importance of object technology and to recognize the impact on their work, users need to know the nature of objects, why objects improve tools, and the technology that is needed for their implementation.

Object technology is based on the newer software development tools that enable design of software as three components. In general, software can be characterized as having a user interface, functions, and data as depicted in Figure 1. The user interface component interacts with the user in a form that should be both understandable and intuitive. Software data are the values needed by the functions to perform algorithms, manage process flow control, and obtain user validation. Software functions are the components that perform calculations and make decisions based on the data. Considering these three components of software will help clarify the term "object."

Not too long ago, a software product was built based on the data important to the user or the work the user would do with the software. Concentrating on the data meant that the user made certain the data were appropriate and expected the software to employ the correct algorithm for the operation. Concentrating on the actions meant that the data were changed to make sure that the software performed the correct actions according to the desires of the user. For example, data-oriented operations are

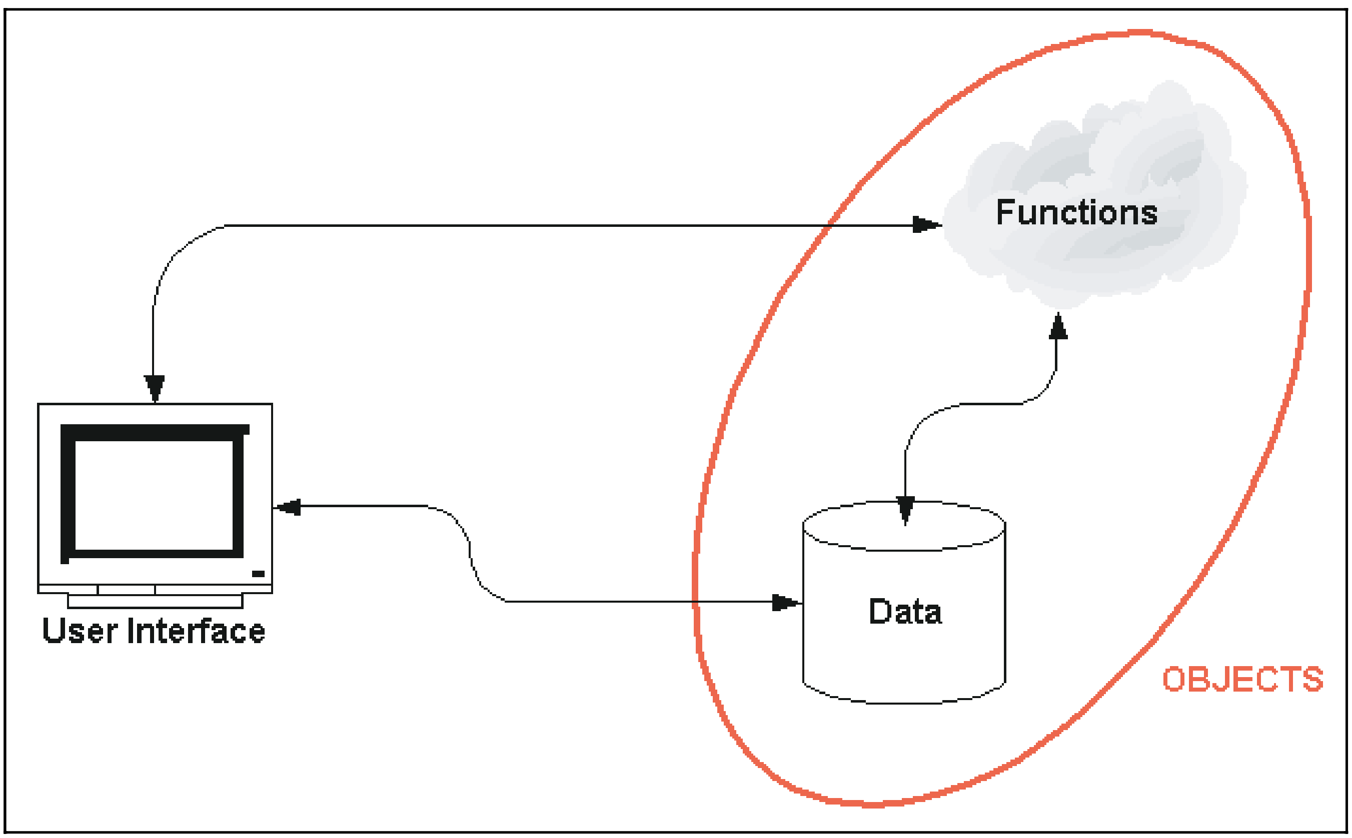

Figure 1. Generalized software architecture

commonly found in database applications like accounting systems. Behavior-oriented operations can be found in prior CADD systems where the user entered whatever data necessary and invoked whatever event necessary to make the product display information correctly. Object technology attempts to relieve the user of this data-versus-behavior decision by grouping, or encapsulating, these two components into an object, shown by the oval in Figure 1.

An object in a software product is a particular instance of an object class. Object classes are collections of reusable software that can be incorporated into software by developers. For example, a class named "Car" will contain all the data and behavior common to all cars. A class named "Dog" will contain all the data and behavior common to all dogs. However, an object named "Fido" that is derived from the class "Dog" contains all the data and behavior of dogs and the unique data of the particular dog named "Fido." In an engineering application, a class named "Door" will contain all the data and behavior of all doors. However, the object "Door1245" that is derived from the class "Door" contains all the data and behavior of doors and the unique data of the particular door for room 1245. These particular data for an object are often not known until the object is needed, so a class will supply default values for the objects in the event that particular data are not immediately available.

Types of Objects

Object classes are implemented in three forms or levels, as illustrated in Figure 2. The lower level contains object classes that communicate between the means of implementation designed by the commercial-off-the-shelf (COTS) software developer and the computer system. These classes are those used to store data and interact with printers, monitors, and the operating system. An example of these classes is the Microsoft Foundation Class (MFC).

The middle-level object classes are those that provide interoperability between applications. These are the common denominator for enterprise processes. Standards organizations will define these classes. Software developers will also define classes at this level for data and behavior that are not yet standardized.

Top-level object classes provide value-added functionality from the application developer based on the middle level. These are produced by the various COTS software developers. These classes are implementations of operations that vendors use to attract buyers of their products. Common examples are a slick user interface, innovative data entry methods, and display windows that change themselves based on the perceived needs of the user. As the standard middle-level objects mature over time, application developers can spend more time improving the top-level objects to attract more users and make the user's time more productive.

A COTS software tool will add value to standard object classes by improving the user interface, optimizing storage of persistent data, and adding more vendor-specific functionality over time. Developing object standards will require respect to the intellectual property of the vendor and the software engineer.

Benefits of Object Technology to Engineers

Object technology enables engineering software application users to use data entered in one application in another application. This interoperability means that data entered into a CADD package would be useable in a cost estimation package, a thermal performance package, a facilities management package, and other CADD packages. The ability to use the same data in various software packages means that if the data are changed in one software package, the change will be recognized in all

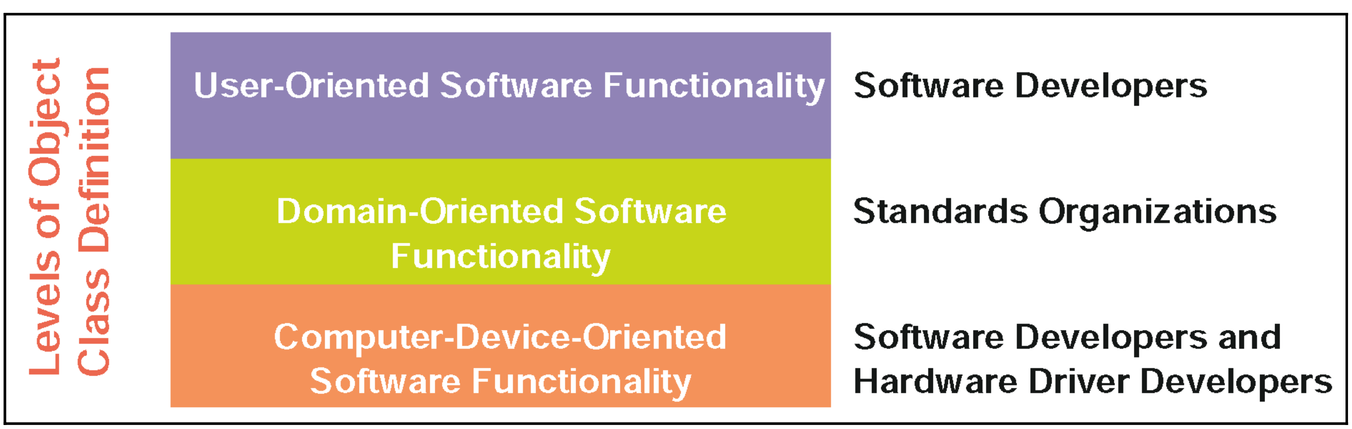

Figure 2. Object Definition Levels

other interoperable software packages. However, for interoperability to become a reality, the domain-oriented software objects must know how to communicate. This is the goal of The CADD/GIS Technology Center's Consolidated Objects Standards project.

Interoperability is the next step toward an enterprise solution to engineering automation. An engineering enterprise, like the Corps of Engineers, will benefit from object standards by using products that conform to a widely adopted standard. This usage is emerging with the International Alliance for Interoperability (IAI) release of the Industry Foundation Class (IFC) library. The IFC library standardizes domain objects so that several software packages can share data. This is available now through vendors that are compliant with IFC Release 1.5.1. Release 2.0 is available to vendors and Release 2x will be available soon. Several vendors have passed IFC compliance testing and have proved the concept interoperability. Standard domain objects enforce data interoperability. The IAI is continuing to define domain data interoperability and produce new domain objects. The organization is also beginning to work on standard behavior of the objects.

Standard behavior will mean that engineering computations will be consistent between applications. Industry standard use of data will mean that buyers, contractors, and sub-contractors will use the same computations within their methods of designing structures.

Conclusion

There has been a great deal of work to begin to realize the benefits of object standardization. However, much more work will be performed by standards organizations. The CADD/GIS Technology Center is working with standards organizations, businesses, academia, and other government agencies to develop these standards. Interoperability using objects will allow application developers to spend more time improving the intelligence within the software and assisting the user. It will enable software to become more robust and should enable engineers to reuse data that another company collected. Software constructed using a tiered approach will be able to perform teaming functions with other vendor's software because the underlying data and behavior are known and there is a communication protocol between the products. The Center is working to make this interoperability a reality for CADD and GIS users.

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Object-Oriented Data Models for GIS

by C. Denise Martin, The CADD/GIS Technology Center for Facilities, Infrastructure, and Environment

The technology trend today is toward object-oriented development. Modern software is built on software component architectures, which divide software functionality into discrete, independent pieces for development and testing purposes, resulting in better quality and performance and a high level of software reuse. Computer-Aided Software Engineering (CASE) tools are used to design and analyze object models based on the Unified Modeling Language (UML), an industry standard diagramming notation. Proprietary macro languages for application development have been replaced with visual programming environments, such as Visual Basic. Much of the object-oriented development is built on Microsoft's component object model (COM). Currently, the major GIS/CADD/database vendors, such as ESRI, Intergraph, AutoDesk, Bentley, and Oracle, are focusing on object-oriented products that leverage current object technology.

ESRI's ArcInfo 8 is the most significant release of ArcInfo, ESRI's flagship GIS. At ArcInfo 8, the georelational data model is extended into an object data model that allows users to add behavior, properties, and relationships to their data. The geodatabase model allows definition of features that more closely resemble the real world. This object data model is extensible for users with more specialized requirements, allowing for user-definable features. This new data model is implemented as an extension to standard relational database technology.

A geographic data model is a representation of the real world that employs a set of data objects to support map display, querying, editing, and analysis. Data models range from:

- **CAD-based models** - binary file formats with depictions of points, lines, and areas, with little or no attribution, to
- **Georelational data models** - geometry data are typically stored in proprietary formatted binary files with attribute data (internal or external) and topological information (internal) stored in relational database tables, to
- **Object-oriented data models** - the geometric, attribute, and topological data are all stored in one relational database.

In the georelational data model, features are generally limited to points, lines, and polygons with "generic" behavior. For example, both a road and a stream are represented by a line feature with behavior defined by topological constraints. In an object-oriented data model, custom feature types and behaviors can be defined that model real world objects. For example, a pipe object could be defined with behavior characterized by a rule such that when two pipes are connected, an appropriate "fitting" object must exist at the point of connection. This type of behavior definition could be (and has been) added to georelational models through the use of application code. As intelligent behavior is added to the data (objects), less application development is required.

In the object-oriented data model, an object represents an entity such as a building, a road, or a pipe and is stored as a row in a relational database table. Attributes describe the object, such as the building number, surface type, size, etc., and are stored as the columns in relational database tables. The geometry of the object is also stored as an attribute in the table. A set of similar objects makes up an object class, such as all the buildings on an installation, and is stored as a table in a relational database.

In building a data model, whether object-oriented or georelational, it is important to remember that there is no single "correct" model. It is an iterative process that requires experience and expertise. A "good" data model should represent all data without duplication, support an organization's business rules, and accommodate different views for diverse groups of users.

Sharability and interoperability are significant goals of the life-cycle management concept. Object-oriented data models could be the key to attaining that goal if they are developed smartly. As users begin to embrace object-oriented geographic data models, it is imperative that standard object models be developed. While data content and naming conventions are the primary focus of the Spatial Data Standards (SDS) to accomplish the goals of sharability and interoperability, the object-oriented data model must also focus on standard object behaviors. Development of standard behaviors could significantly reduce the amount of customized applications that are currently being developed. Just as numerous applications have been developed to customize the behavior, or function, of geographic features, objects will be, and are being, developed in an ad-hoc manner with custom designs and behaviors. Additionally, the Architectural, Engineering, and Construction (A/E/C), Geographic Information System (GIS), and Facility Management (FM) communities are developing object models with little collaboration. A synergistic A/E/C / GIS / FM approach to object model development would greatly facilitate the goals of life-cycle management.

With this in mind, the CADD/GIS Technology Center has begun an effort to develop a consolidated geospatial data model using object-oriented technology. Recognizing the scope of this development, several prototype efforts are ongoing and/or planned to facilitate this technology change. In conjunction with ESRI, the Center staff is working to define an SDS geodatabase implementation. In so doing, the Center will be able to move with and help lead the industry in developing a standard object-oriented data model before legacy implementations are developed.

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Coming in the Next Issue...

The next issue of the CADD/GIS Bulletin will feature Web-based technology. One of the highlights will be the survey results of a telephone survey conducted during March 2000 by Ms. Terri Prickett, ERDC Coastal and Hydraulics Laboratory. The survey was designed to assess the CADD/GIS professionals' awareness, adoption, and use of the on-line CADD/GIS Bulletin.

Move Management: The Latest Focus for the International Alliance for Interoperability (IAI) Facility Management Object Domain Group

by David H. Horner, The CADD/GIS Technology Center and Chairman of the Facility Management Domain Group

As a concept, move management seems simple—move people and things from one location to another in an orderly and timely manner. However, when someone tries to document (or model) the steps required to make such a move, the process becomes much more involved and difficult to explain. For the typical move, the process looks something like Figure 1.

Obviously, for large organizations, this process can become difficult to plan and expensive to execute—two prime reasons to automate!

As part of its mission, the International Alliance for Interoperability (IAI) is standardizing many business/process models like move management so that they can be automated. These models are used to establish consistency and interoperability among software application developers and to ensure that data created can be shared among the vendors' various applications.

The Facility Management (FM) Object Domain Group (one of the IAI's working groups) used a unique process called a "charrette" (an intensive short-term work session designed to accomplish well-defined goals) to fast track the development and completion of the move management model. By using these charrettes, the FM Object Domain Group was able to condense the typical 30-month developmental cycle to less than 14 months.

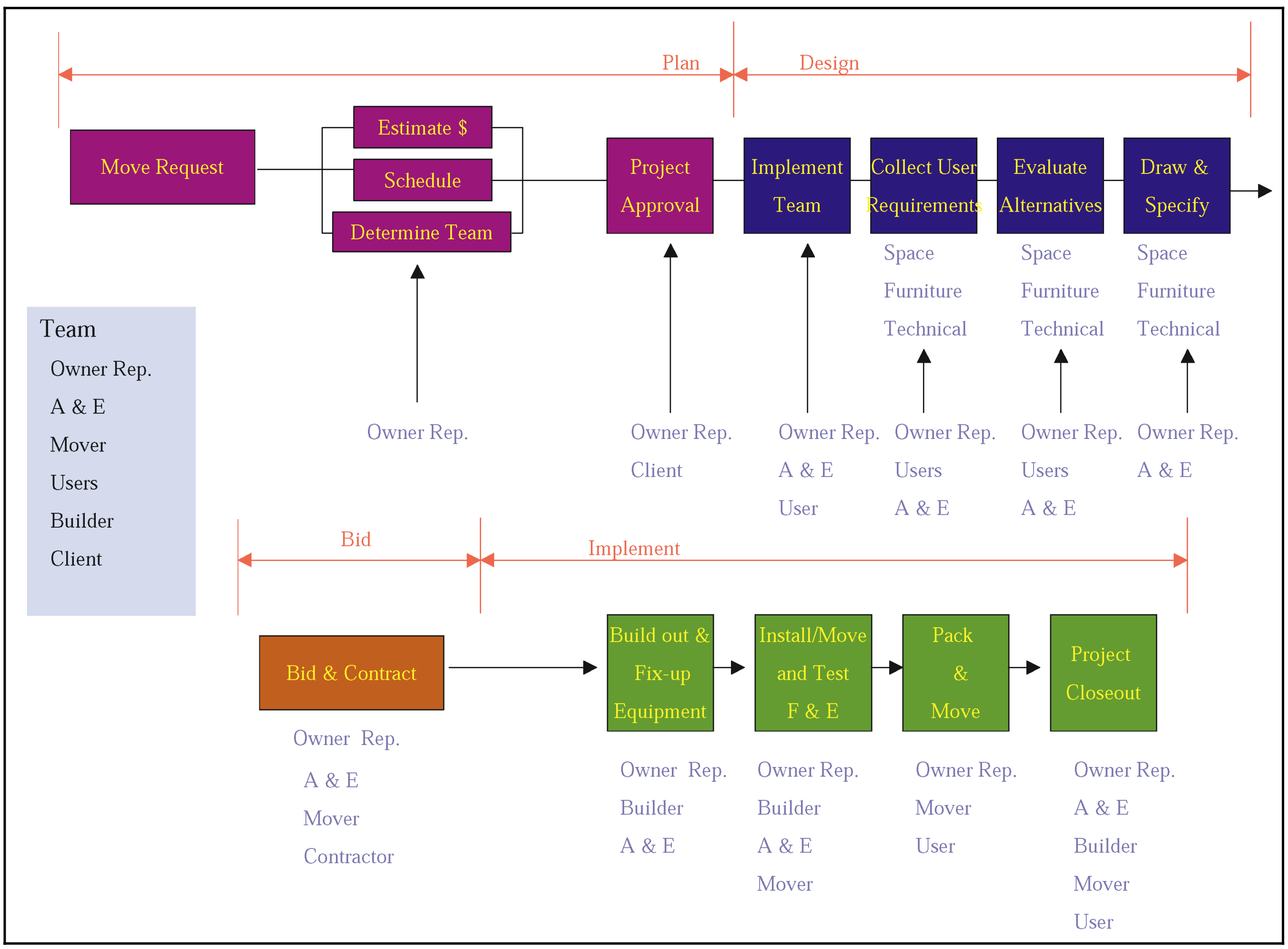

Figure 1. Model of typical move process

The FM Object Domain Group also included a space validation and an integrated process model for Application and Work Order Control, Work Order Management, and Asset Management. The test case plan produced model and development processes for moving components from Room 1 to Room 2, as shown in Figure 2.

The actual process was developed at the Civil Institute for Facilities Engineering (CIFE) at Stanford University. The FM Object Domain Group further refined the model and process over the next four charrette applications to:

- Review of available content in Industry Foundation Classification (IFC) R2.0 model and establish what worked and what needed further effort.
- Build a global model for FM concepts taking into account everything in IFC R2.0 that could have an effect on FM.
- Break the model into parts and test these against previous parts.

At the end of the four charettes, an improved Work Order flow and more generalized use of work schedules evolved. Specifically, maintenance Work Order subtypes were added to manage specialized information, and the concept of a Maintenance event was added to relate Work Orders to assets (promoted from property set to class). The Maintenance Record is now dealt with as a list of maintenance events, which reflects more closely how software applications approach this situation.

The model has been released to industry and is being included in current releases of Archibus FM, Peregrine Systems-SPAN FM, VISIO-FM, and Work Place Systems software. The FM Domain is currently redefining the project tasking and FM objectives to include Building and Component Management, Functional End-Use Management, Property Management, Utilities Management, and Security Management. These processes will be established and new work identified within the next year.

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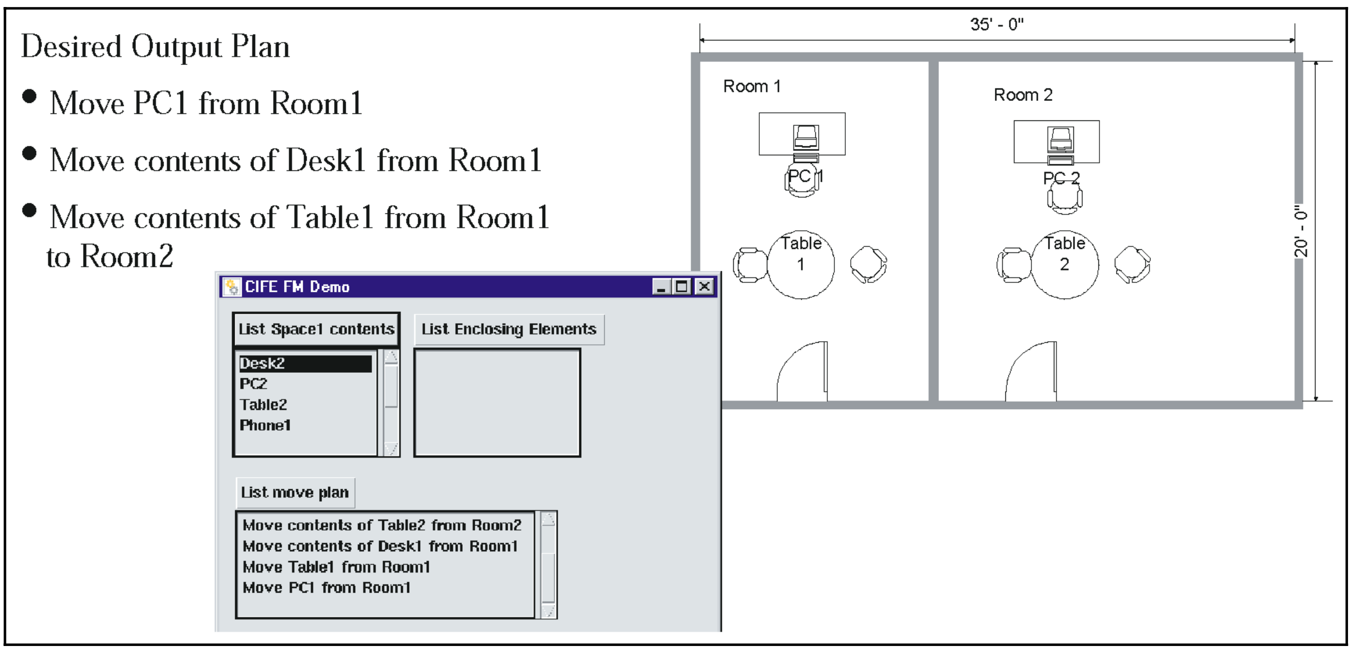

Figure 2. Model and development processes for moving components from Room 1 to Room 2

Airfield Obstruction Management System

by Frank McCann and Lance Bedard, Higginbotham/Briggs & Associates and
Bryan Perdue, The CADD/GIS Technology Center for Facilities, Infrastructure, and Environment

Computer-based resource management is employed in a variety of areas within the Department of Defense (DoD). Extending this trend to include airfield management is a logical step toward the realization of an enterprise-wide management system. DoD owns and/or operates hundreds of airfields worldwide that range in size from small Class A runways capable of handling only light, fixed- and rotary-winged aircraft to the larger Class B runways capable of handling larger transport aircraft. Each of these airfields exists in a unique, constantly changing environment requiring careful management of existing and potential obstructions. The safe operation of these airfields is contingent upon a very complex and challenging planning process.

Ideally, airfields are located in open, unrestricted areas having few, if any, obstructions to hamper flight operations. However, with rapidly changing technology, growth in and around installations, and competing interest for limited resources, this is not always the case. Most airfields have numerous permanent and/or temporary obstructions, located either on the airfield itself or in the immediate vicinity—posing a danger to safe flight operations. Wherever obstructions are located, airfield managers must assess the impact of the obstruction(s) and, where appropriate, minimize or eliminate the potential hazard. In response to these needs, Higginbotham/Briggs & Associates, Colorado Springs, CO, has developed a solution that combines the power of ESRI's ArcView and Microsoft's Access software programs—the Airfield Obstruction Management System (AOMS). AOMS is designed to meet the needs of the airfield manager.

Key Features

Design goals for this application included ease of use, minimal training requirements, and installation level maintenance. These goals have been achieved through the use of commercial off-the-shelf software already widely in use throughout DoD and many other government agencies. ArcView provides the graphic engine that allows obstructions to be viewed using existing map data with the added benefit of overlaying ortho-rectified aerial photography, if available. Individual digital photographs relating to each obstruction can be included and viewed as needed. This visual information is linked to the CADD/GIS

Technology Center's comprehensive Spatial Data Standards (SDS) and an Access database (Figure 1) that provides tabular information relating to the obstruction, including its description, dimensions, imaginary surfaces/zones violated, and other critical data elements.

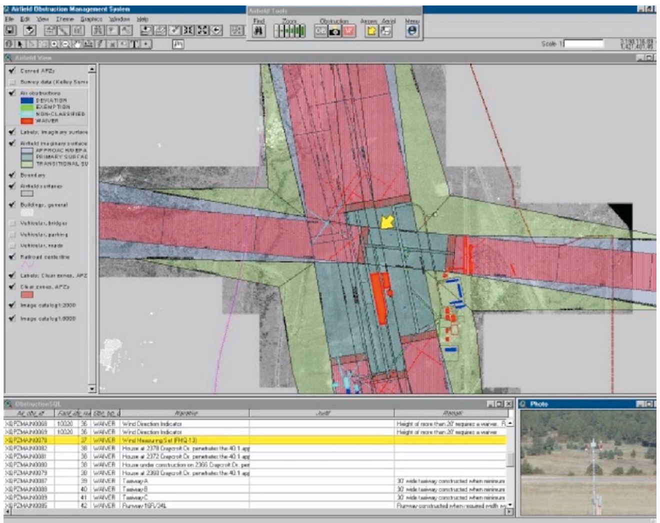

Figure 1. Visual information linkage

Additional features include automated waiver generation and tracking functions (Figure 2). It also provides the capability to scan and maintain documents and the ability to associate them with a particular obstruction. A comprehensive user's manual included with the application provides step-by-step instructions for the data manager who maintains and updates AOMS and for the end users.

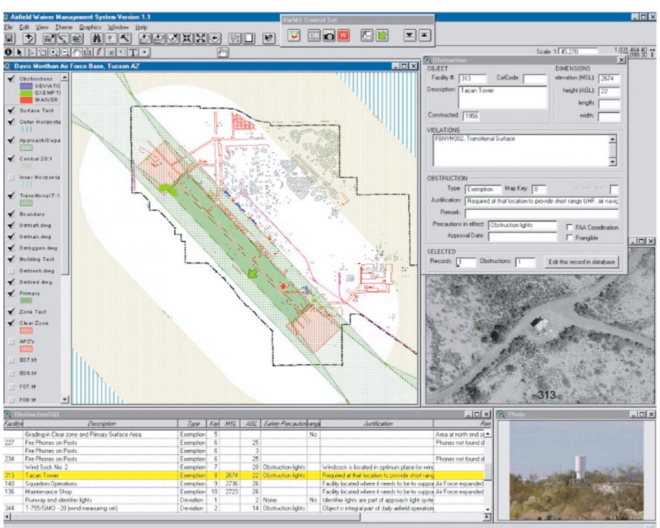

Figure 2. Automated waiver generation and tracking functions

Benefits

The benefits of using an application as versatile as AOMS are readily apparent. Of particular importance is its alignment to a standardized database. Over the years, installations and major commands throughout DoD have focused on different elements of information essential to their particular aircraft operations. Although each installation's unique problems were addressed, it is difficult to coordinate data between the different organizations on the installation and with their major command. AOMS allows users to focus on elements specific to their installation, yet provides a common interface with standardized data fields (Figure 3). This is made possible by incorporating the SDS as the underlying data structure. By using the SDS, AOM*S* provides a reasonable assurance that data consistency is maintained.

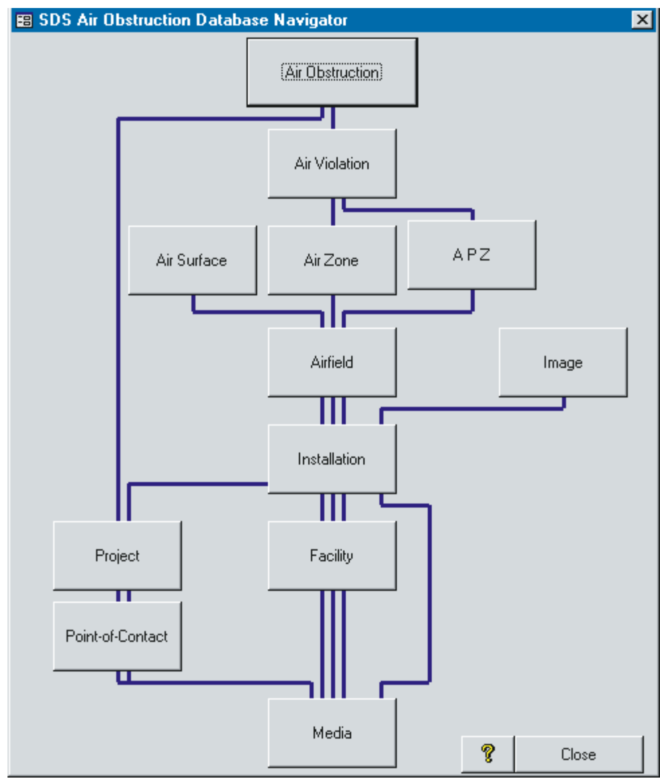

Figure 3. Data structure

AOMS provides airfield managers a better tool to depict the true nature of an obstruction (a picture is worth a thousand words) and allows airfield managers to maintain a wide range of easily accessible data (Figure 4). Information that once required several man-hours searching through files to obtain can now be accessed by AOMS in a matter of seconds. Combined with the power of a common relational database, managers have a more effective and concise method of relaying accurate data to the

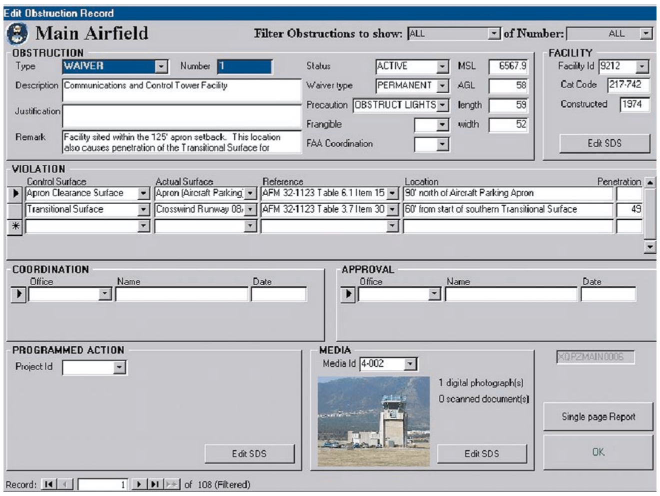

Figure 4. Edit table accessing relational database

decision-makers either locally between organizations or with higher headquarters. Siting decisions are also enhanced because airfield-related constraints can be shown on a single image.

Another benefit of AOMS is that the system can be operated on an installation's local area network. Server-based, read-only access to the application can be given to clients anywhere on the installation, providing wide dissemination and use of the information while protecting the integrity of the data.

AOMS is designed to link with existing map data—eliminating the need to maintain multiple electronic map sets. The user establishes the link to the organizational server supporting the "installation map." Each time the application is started, the user automatically accesses the most current version of the installation map. The database aspect of AOMS operates a little differently. Since most installations have yet to adopt the SDS as their standard, existing data will require conversion to this structure. However, SDS also allow for the use of "local tables" that can be linked and used "as is" to provide additional information for all users.

Summary

AOMS is designed to bring the power of information to users who are not computer technicians but whose jobs require access to technical data. Its underlying strengths are increasing exposure to and knowledge of airfield operations, capturing and maintaining mission-critical data, providing a common database structure and interface, and making the entire package easy to use.

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Object Relational Databases

by Nancy Towne, The CADD/GIS Technology Center for Facilities, Infrastructure, and Environment

A database is an organized collection of information. For management purposes, a database management system (DBMS) is needed to store, retrieve, and modify data in the database on request. There are four types of databases: *hierarchical, network, relational,* and *object relational*. This article focuses on object relational databases (Figure 1).

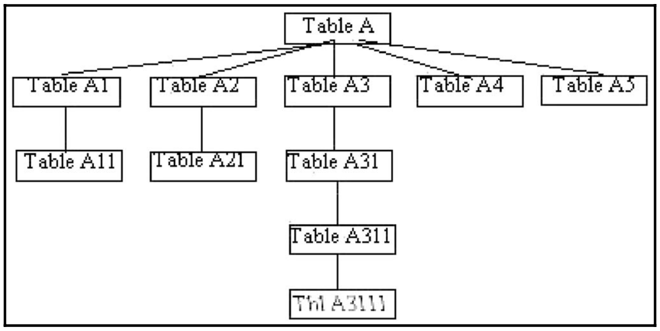

Figure 1. Object relational database

A relational database uses relations or two-dimensional tables to store information. The object dimension gives the added component of spatial data. Spatial data include any information with a location component. Databases with geographic references, such as addresses, phone numbers, and postal codes, may now be analyzed using a service known as geocoding. Fundamental shifts are occurring in the way enterprises want to access, disseminate, analyze, and store their information. Many people are realizing that if they could augment their traditional relational data with rich new data types like spatial, video, and unstructured text and make these easy to manage, they could see dramatic improvements in the capability for strategic decision-making, productivity, and ultimately lower operating costs. The ideal solution is an enterprise-wide information infrastructure that includes a single database system for managing spatial data, with a data structure that is independent of the application.

Two major suppliers of databases, tools, and application products are Informix Corporation and Oracle Corporation. Oracle has introduced a spatial component to their Oracle7 RDBMS, hence Oracle 8*i* or Oracle Spatial. Informix has introduced Formida Fire Spatial DataBlade to their Dynamic Server. Both of these spatial components allow users and application developers to seamlessly integrate their spatial data into enterprise applications and fully leverage the scalability, reliability, and performance of the database.

Spatial analysis is based on the spatial relationships of these data, like the proximity of airfields to residential areas within a given distance and noise levels in the vicinity. The spatial component expands RDBMS capabilities to support all data, with an integrated set of functions and procedures that enable spatial data to be stored, accessed, and analyzed quickly and efficiently. This means that spatial and attribute data can now be managed in one physical database, thereby reducing processing overhead and eliminating the complexity of coordinating and synchronizing disparate sets of data. This does not eliminate the need for GIS software applications, which have a rich and varied suite of spatial analysis tools.

By providing an open architecture for the management of spatial data within a database management system, the functionality is completely integrated within the database server. Users define and manipulate spatial data through Structured Query Language (SQL) and gain access to standard features such as a flexible n-tier architecture, object capabilities, robust data management utilities, and Java-stored procedures. This ensures data integrity, recovery, and security features. In addition, a new geocoding framework facilitates address matching, storage, and retrieval of geocoded spatial point data, as well as within-distance query capability, from within spatial databases.

Since spatial data are being stored in relational tables or as objects (abstract data types (ADTs)), there is a necessity for new object data types, which are:

Object References (REFs)

Object Instances (Objects)

Nested Tables

SDO_GEOMETRY (spatial data object)

VARRAY (variable-size array)

BLOB (binary large object), CLOB (character large object), NCLOB (non-character large object), and BFILE (binary file)

The use of the object types enables spatial data to be stored, accessed, and analyzed in a spatial database. This set of analysis tools is limited and does not replace the need for a GIS software application to fully utilize the spatial data. Users can define and manipulate spatial data through SQL, GIS applications, and gain access to standard features, enabling them to utilize their time and resources. The spatial component addition to relational databases is a major technology enhancement for GIS software vendors. It will enable the use of objects and complex features, which will be discussed more fully in the next issue of the bulletin. Discussions of GIS software applications, spatial RDBMS, and objects will also be included.

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Natural and Cultural Resources Forum

by Laurel Gorman, The CADD/GIS Technology Center for Facilities, Infrastructure, and Environment

This column highlights several meetings and conferences that focused on management issues and the latest geospatial applications for natural and cultural resources. Two major events, the CADD/GIS Symposium and the Army-sponsored Integrated Training Area Management (ITAM) Workshop are featured in this issue.

Symposium Highlights - It was a busy week for the Natural and Cultural Resources Field User Group (FUG). Starting off on Monday, May 21, 2000, the members met all day to develop the Center's Fiscal Year 2001 (FY01) business plan and FUG projects. New officers were elected: Kevin Porteck as Chair and Jeff Foisy as Vice-Chair. During the meeting, several users from installations and District offices participated in the discussions and added their experiences at their respective offices. We also welcomed Odean Sarrano, from Headquarters, National Aeronautics and Space Administration (NASA), who described the natural and cultural resources initiatives ongoing throughout the NASA organization and would inform the group of future collaborative work.

In the afternoon, the group discussed this year's project and scope of work and then refined the FY01 project proposal. The FY00 project "Geospatial Data Content, Analysis, and Procedural Standards for Cultural Resources Site Monitoring" will identify draft standards as a method for cultural and natural resource managers to document complex, three-dimensional features, such as rock art panels, burial artifacts, and fossils, at field sites. Utilizing the latest geospatial technologies and procedures will allow expedient and accurate data recordation and analysis. For further details, please check the FUG home page at *fsc.wes.army.mil/contacts/groups/FWG/Natural-Cultural/.*

Tad Britt hosted the technical session for natural and cultural resources on Tuesday, May 22, 2000. There were three informative presentations, including an overview of the Natural and Cultural Resources FUG activities, partners, and activities related to the Mojave Desert Ecosystem Program, and an enterprise-wide GIS model for natural and cultural resources. However, it was not all work. Many of the members got together at lunch and in the evenings to visit the local sites and to catch some baseball games at the Busch Stadium.

ITAM Workshop - Army users focused on GIS and natural and cultural resources issues at their 9th annual ITAM Workshop held at Fort A. P. Hill, VA, on August 21-24, 2000. Paul Dubois, ITAM GIS coordinator, organized one full day of GIS issues that included metadata, Spatial Data Standards (SDS) implementation, latest on Web Map Server, global positioning systems and GIS, and software applications supporting the Army mission. Standardization of the GIS database was a high priority for the ITAM GIS User Working Group. Denise Martin and Laurel Gorman, from the CADD/GIS Technology Center, held a mini-training session on the SDS and participated in the Military GIS Discussion Forum led by Josh Delmonico. Installation users were enthusiastic about the browser, tool bars, and new features in the SDS application. During the rest of the week, two special sessions were held on Land Condition Trend Analysis and the Range and Training Land Program. Installation GIS users shared their experiences, particularly with data warehousing, training GIS applications, interfacing with wind and soil erosion models, and monitoring strategies. Visit the ITAM Workshop Web site at *www.army-itam.com/main.htm/* for the final Proceedings and Workshop activities. The latest ITAM news and field experiences are posted in *The Bridge* newsletter.

ERDC Center for Natural Resources - A new ERDC-center of expertise, the Natural Resources Research and Development Center (NRRDC), was formed this spring (May 2000). The charter of the NRRDC promotes a holistic approach to natural and cultural resources research and development (R&D), technical assistance, and stewardship within the DoD. The NRRDC focuses its activities on:

Providing a point of contact for natural and cultural resources R&D and technical assistance.

Improving information exchange and coordination on natural and cultural resource issues, programs, and research.

A landscape-based, watershed-level approach to resource characterization, analysis, and management.

As a first year initiative, the NRRDC will pursue environmental restoration issues and a workshop. The NRRDC is led by Dr. Dave Tazik (*Dave.J.Tazik@erdc.usace.army.mil*) as Director and Dr. Jean O'Neil (*L.Jean.O'Neail@erdc.usace.army.mil*) as Assistant Director. Both are from the ERDC, Environmental Laboratory. Visit the NRRDC Web site at *www.wes.army.mil/el/nrrdc/nrrdc.html* for additional information and available technology applications.

Field User's Input - On behalf of the Natural and Cultural Resources FUG, I invite you to contribute articles or comments to Laurel Gorman at 601-634-4484 or *Laurel.T.Gorman@erdc.usace.army.mil.*

A/E/C SYSTEMS 2000

E-Solutions for the A/E/C Industry

by David M. Johnson, The CADD/GIS Technology Center for Facilities, Infrastructure, and Environment

The focus of the annual A/E/C Systems Conference was the integration of the Internet with the entire design and construction process. For the more than 16,000 who attended the show from June 5–8 in Washington, D.C, the focus was on linking software to the Internet and to each other. Although the show had eight tracks ranging from architecture to construction management to GIS and Mapping, the highlight of all the presentations by vendors was their Internet capability. (Check out the vendor sites at *www.aecsystems.com/aec2000/finallist.htm*.)

The Keynote speakers, Dr. Joel Orr, President of Orr Associates International, and Mr. John D. Macomber, President and CEO of Collaborative Structures, Inc., presented the future of the industry and its dependence upon an organized Internet-related process via extranets. (Link to the following site to hear these addresses: *www.designarchitecture.com/aecsystems/*.) Specialty workshops covering the eight tracks were held, and the related reference material is located at *www. aecsystems.com/aec2000/workbooks.htm*.

Creating a simpler, more intuitive three-dimensional (3-D) modeling ability was this year's emphasis by the CADD vendors: Revit (*www.revit.com/*), Graphisoft (*www.graphisoft.com/*), DataCad (*www.datacad.com/*), VectorWORKS (*www.nemetschek.net/*), and Arris (*arriscad.com/download.html*). By anticipating the tools the architect/engineer will need and making the tools easily accessible and logical, the programs make 3-D design more practical.

Both Revit and ArchiCAD use parametric drawing capabilities for 3-D design modeling. Revit is a new product based upon Pro-E software, a solid modeling engineering software not generally used for the building industry. As a new product, it lacks the extensive object libraries that other architectural software packages have. The use of the American Institute of Architects' (AIA) layer designation was observed on many products. Most CADD software seems to be migrating to the National CADD standards by various degrees. With 3-D software, there must be a separate group of information that refers to a 3-D object's 2-D symbology or properties. A single 3-D wall must have information to represent the wall in section as well as in plan view to allow the wall to be presented with the correct symbology for the sheet files.

It was surprising that there was little emphasis on MicroStation or AutoCAD CADD software, especially their 3-D architectural packages, Autodesk's Architectural DeskTop and Bentley's TriForma.

There was a focused effort to attract those who were already using these systems to extend their capability through Internet collaboration. Bentley's main emphasis was enterprise-type Internet project management to encompass the entire process of design, construction, and management for multiple projects with multiple accesses.

Other highlights of the show included:

(1) Companies that are basically information portals for making quick access to various construction resources and providing some individual user functions (such as BuilderSupplyNet.com, Cephren, SupplyFORCE.com, OnBedrock.com, and PrimeContract).

(2) User services that can link a project team and send group pages or e-mail, or allow access to bulletin boards or provide instant up-to-date pricing or availability of materials.

(3) Companies that provide information services as well as document storage and distribution (such as viecon.com, buzzSaw, and Bidcom).

(4) Companies that specialize in document and information transfer, linking multiple project teams and organizations with complex structures (for example, Framework Technologies).

The objective is to give the users access to a wider range of sources, to connect people and information instantaneously, and to provide new tools that only the Internet offers. Companies are changing rapidly and increasing their resources as well as their capabilities. It is important that the user analyze the resources needed, examine the companies and their capabilities and directions for growth, and then re-analyze what is needed based on the user's own anticipated growth and the wealth of resources available.

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